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ABSTRACT

This document shows how computer technology can aid educators in meeting demands for improved class scheduling and more efficient use of transportation resources. The first section surveys literature on operational systems that provide individualized scheduling for students, varied class structures, and maximum use of space and staff skills. Computer programs for bus routing and scheduling are discussed in the second section. Several of the documents reviewed include detailed sample programs illustrating the techniques discussed. (Author)

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October 1971 Number 1

Computer Applications in Class and Transportation Scheduling

Philip K. Piele

The application of computer technology to the reporting, data analysis, planning, and evaluation activities of educational management has produced dramatic changes in the environment of contemporary education. Computer-based aids enable school personnel to devote more of their attention to the changing needs of students and the community at large. This has in turn resulted in an increased experimentation in the interaction of computers with learning techniques and management systems.

The literature on computer applications theory is broad and varied. In keeping with the goal of this series—to provide access to relevant documents that may be of specific use to the practicing administrator—the materials cited in this review deal with operational systems. All but four of the documents reviewed are available from the ERIC Document Reproduction Service. Complete instructions for ordering these documents are given at the end of the review.

CLASS SCHEDULING

The demand for improved class scheduling is one of many interlocking needs facing today's educator. Innovative curricular reform cannot be accomplished without providing the administrator and teacher with more time for making exploratory decisions in individualized student programming.

In recent years a number of research and implementation studies have examined the feasibility of replacing the restric-

tive, manually constructed schedule with a variety of computer-based programs. The bulk of this experimentation has been focused on the university campus. However, with rising interest in the adaptation of modular and other university-originated scheduling techniques to secondary education, the literature indicates the development of several extensive studies on the high school level.

Several documents concentrating on computer applications in a university setting are included as an aid to the secondary school educator because many of the problems and almost all of the terminology can be readily translated to the contemporary high school's management tasks.

Stanford School Scheduling System

A booklet published by the Stanford University Department of Industrial Engineering and School of Education (1968) gives a general overview of the Stanford School Scheduling System (S-4 or SSSS).

The document surveys innovations in flexible scheduling and variable course structure designs in secondary education, discusses the school scheduling problem, and outlines schedule construction using the S-4. It also covers field testing of the system and its limits, and describes computer system requirements.

The S-4 has the following advantages: (1) it is a technology that enables the construction of complex flexible schedules; (2) it requires precise definition of the design of each course offered in the school program, as well as of the overall program design; and (3) it encourages professional personnel to explore in detail the appropriateness of different arrangements of time, class size, pupil grouping, and use of staff and facilities. The final section describes the availability of technical documents and the set of programs for the S-4 written in FORTRAN IV for IBM systems 360-40, 360-50, or 360-67.

Bergquist (n.d.) describes the four sequential programs that constitute the S-4. The first program, CTTA (card to tape and audit), directs the computer in automatically checking for more than one hundred types of omissions and inconsistencies. When all detectable errors have been eliminated, the program directs the preparation of course data packets including detailed information on each course.

The second program, SSP (school scheduling program), builds the course data packets into a preliminary master schedule. It selects time patterns, assigns teachers and rooms, and updates records affected by such assignments.

The third program, PTWS (program to write schedules), does the sorting to convert the class lists to teacher schedules, room schedules, and individual student schedules.

The last of the four programs is called Translate. It translates the computer's numeric codes into names and numbers that can be read by and are relevant to the individual school. Supplementary programs include updating after manual change, SAP (the student assignment program), RAP (room assignment program), and UDCL (update class list). None of these programs accomplishes curriculum innovation, but each can provide the time and means for achieving that goal.

According to Allen and De Lay (n.d.) the S-4 can free administrators from the burden of scheduling without loss of opportunity to make vital educational scheduling decisions. Since experimentation with a range of curriculum alternatives requires flexible scheduling, the restrictions of manual scheduling techniques must be removed.

The computer can provide maximum freedom to choose a schedule reflecting the abilities and interests of students and the special qualifications of teachers. In a few seconds it can investigate the millions of possible combinations of teachers, students, rooms, and limits of time, thereby satisfying a high percentage of student schedule requests. Furthermore, the S-4 costs of approximately $1 per student are comparable to costs of manually constructed schedules.

Allan (1964) and Petrequin and Tapfer (1968) describe Stanford's field implementation of computerized modular scheduling at the Virgin Valley High School in southern Nevada and at Marshall High School in Portland, Oregon.

After examining the responses of students and teachers at the Virgin Valley High School, Allan reports that the first year of operation yielded greater opportunities for individualized instruction, increased curriculum offerings, released time for teacher preparation, and improved student and teacher attitudes toward learning. At that school, the university's Computer Computation Center employed thirty-minute modules with a total of eighty modules per week to develop schedules for 165 students and assignments for fourteen teachers.

Petrequin and Tapfer show similar results generated with Stanford's assistance in flexible-modular scheduling at Marshall High School. There, staff members attended in-service training workshops and explored experimental techniques such as team teaching in preparation for the new instructional program.

When the program was implemented, the basic schedule was changed from the conventional seven-period day to one divided into twenty-one modules of twenty minutes each. With advisory help, students preregistered in the spring for the following year and the computer utilized their schedules to prepare the master plan. Flexibility was enhanced through the adoption of four teaching-learning modes: large-group instruction, medium-sized groups for laboratory activities, small-group learning experiences, and independent study situations.

Generalized Academic Simulation Program

Murphy and Sutter (1964) compare the manual method of developing a school schedule with the new computer method of Generalized Academic Simulation Programs (GASP). They point out that the computer allows considerable leeway in setting the parameters for the scheduling of subjects and facilitates the flexible scheduling of students by avoiding human shortcomings inherent in manual approaches. Nor is the system limited cybernetically to scheduling tasks.

Through the implementation of an automated scheduling program an administrator receives an operational understanding of the computer's language and potential that relates directly to more complex "strategic" decision-making responsibilities.* The combination of this understanding with the administrative and staff resources freed by the computer motivates the exploration of

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*The utilization of computer technology in class and transportation scheduling falls within a larger category of computer theory known as *management information systems (MIS)*. The documents discussed in this review are related to what is called the "operational" level of computer applications. Some mention has been made of the management and strategic levels of computer application, but these areas have been largely ignored since each in its own right represents complex considerations demanding special and separate attention. Readers desiring a more detailed perspective of this entire field may obtain copies of a state-of-the-knowledge

"what if" questions and "educational assumptions" that in the past could only be imagined but never implemented for lack of computer programming and its accompanying ability to predict outcomes.

The GASP technique receives further analysis in Chaffee and Heller's report (1967) on the principal conclusions of the Project in Automated School Scheduling (Project PASS). The Western New York School Study Council instituted the project in 1965 to explore the feasibility of inservice education for school personnel contemplating automated approaches to school scheduling. In addition to the GASP system, the study utilized the Class Leading and Student Selection (CLASS) technique and scheduled two pilot schools for New York with both processes.

The project yielded two sets of data concerning the costs and personnel commitments required for each technique, and the special personnel competencies required for data collection and preparation. In addition, the study obtained information about the alterations in scheduling procedures necessary when changing from CLASS to GASP, and analyzed the efficiency of the GASP-generated master schedule in relation to the conventional hand-developed schedule. Analysis of the data shows that CLASS and GASP cannot be compared in terms of their ultimate objectives because CLASS is a "sectioning" technique, while GASP develops a master schedule.

Other Approaches

The Western States Small Schools Project (WSSP) provides a wide variety of curriculum offerings and meets individual student needs through computerized modular scheduling techniques. Jesser and Stutz (1966) describe the exploration, development, and operation phases of the WSSP experiments and discuss administrator and consultant involvement with the computer aids necessary for such undertakings.

Phay and McCary (1968) supply a method for the accurate computer accounting of space and room use by regularly scheduled classes in institutions of higher learning. Based on well-defined terms, a master room schedule and a master course schedule are prepared on computer cards. This information is then compared with the reported individual room usage. Printouts are made in tabular form for unassigned classrooms and class laboratories, courses unlisted in utilization tables, room use, percentage of occupied rooms, "other room" use, room use for all room types by department, number of students, and percent of total in assigned classes.

University Scheduling Systems

Two papers by Abell and others (1965) deal with a Comprehensive University Scheduling System (CUSS) aimed at achieving uniform and efficient utilization of staff and physical facilities and developing a schedule that permits the maximum number of students to fulfill their curricular requirements.

In "An Introduction to CUSS," Abell describes the development of this system at Purdue University's main campus and discusses its successful application at Seattle

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paper on "Educational Management Information Systems: Progress and Prospectives," by John A. Evans, senior systems analyst for the MITRE Corporation. The paper is one of five commissioned by the Clearinghouse and published by the Center for the Advanced Study of Educational Administration in a monograph entitled *Social and Technological Change: Implications for Education.* Copies of the monograph can be purchased at $3.75 each from the Center for the Advanced Study of Educational Administration, University of Oregon, Eugene, Oregon 97403.

University and at Purdue's regional campuses in Indianapolis and Calumet. He also details the system's three operational phases—resource planning, execution, and utilization measurement. A flowchart and sample input information illustrate the explanation. According to Abell, research was underway to alleviate the general limitations of CUSS that deter its expansion to the large-scale, main campus scheduling.

In a second paper in the report, "Bookmaker: Version I of a Computer Program for Schedule Construction," Morgan describes the philosophy and logic behind the second, or execution, phase of the system, where schedule construction takes place. He points out a unique feature of this phase: it can be weighted to give priority to staff wishes, student wishes, or classroom utilization in schedule design.

In a related document, Abell (1965) presents an operational record of the Purdue Academic Student Scheduling (PASS) system and describes its structure within the total registration process. The primary goals of PASS, a "choice-course" system, are to satisfy student program requirements and, operating from a total assimilation of inputs, to distribute class loads equally through the master schedule. A structure of academic concepts and associated goals underlies the directional philosophy of the programming system.

Major emphasis is put on aligning the class assignment process within the entire operation of the academic year and on providing opportunity for meeting unusual student needs. The key to this network of control, according to Abell, is the centralization of master schedule construction in the Office of Schedules and Space. In addition, the manual details the operational procedures and functional relationships involved in the assimilation of student requests, faculty resources, and space utilization requirements.

The system uses COBOL and the IBM 7090 computer in the correlation of student requests and class schedule input materials. Abell's appendixes include representative samples of forms, input documents, reports, and output control information for the administrator contemplating related computer applications.

TRANSPORTATION SCHEDULING

Indirectly related to experimentation in flexible learning situations is the increasing application of computer aids to transportation routing and scheduling. The administrator contemplating a more diversified and student-centered curricular program must face related complications in getting students to and from the school facility. In addition, an increasing interest in satellite facilities and an established recognition of field trips as valuable learning experiences indicate that the efficient mobilization of transportation resources will occupy a prominent position in the duties of tomorrow's school managers.

As administrators learn to apply computer assistance to the solution of strategic decision-making problems such as those related to the growth and size of the school district and the projection of population trends in relation to the surrounding community, transportation scheduling will evolve as an integral segment of management's computer-based data spectrum.

The six documents reviewed here provide a survey of the research in this area. Like the documents on class scheduling, several include detailed sample programs illustrating the techniques and approaches discussed.

According to Tracz (1970), the reorganization of school administrative structures, the availability of new technology, the in-

creased competition for limited resources, and the changing patterns of communication suggest an increased need for quantitative analysis in the school district decision-making process. Student transportation is one area of decision-making that is highly adaptable to such analysis.

The prevailing manual approach to bus scheduling and routing is time-consuming and requires an excessive amount of administrative talent. Bus routing with optimum service and safety at minimum cost requires an interaction between man and machine that utilizes a computer for the performance of complex mathematical calculations and allows for administrator intervention when necessary.

Tracz reports that additional benefits accruing from computer-designed bus routes include simulation capability for planning, and increased management control. For most school districts, quantitative analysis of operations will require basic changes in staffing and data-collection procedures. Increased efficiency in subsequent years should more than offset the high initial costs.

In another document, Tracz and Norman (1970) detail the development of a computerized bus system occasioned by a reorganization of the school districts in Ontario, Canada. Their report describes the procedures that reduce time and effort in producing bus routes and includes a series of tests designed to check the feasibility of the proposed program and to perform an evaluation of the overall procedure. The appendixes contain information for setting up input control cards and a sample of the output from a typical problem.

Isaacs and Simon (1966) report on their investigation and research for an automated bus utilization and scheduling system. The development of this system would involve (1) program design and computer selection, (2) coding of the supervisor program and related programs, (3) program checkout, (4) data conversion, (5) system verification, and (6) final documentation, including detailed program documents and a user manual presenting system concepts, machine specifications, and operational procedures. The report incorporates a system design and operational program flow. Because of insufficient time, the project was not completed.

Ross and others (1969) describe a study concerned with the use of a computer (in the IBM 1620 symbolic programming system (SPS) programming language) in designing school bus routes. Other objectives were to expand and refine the program, increase its speed, and reduce its costs. The revised program offers school administrators and transportation department heads an effective method of coping with the clerical tasks involved in school bus routing.

Ross provides the concluding report of the project, converted into the FORTRAN language. The FORTRAN program yields the following outputs in terms of costs: bus routes with variable descriptions of pickup points, times of arrival at and return to a point, total student riding time, and total bus time. Several school systems have thoroughly tested the program.

A report by Newton and Thomas (1970) outlines a computer-based method for translating available data about schools, students, and bus facilities into a set of bus routes and schedules prior to the start of the school year. Via the computer model, each route can be designed to satisfy student riding time and bus capacity constraints and at the same time minimize the total bus travel (including running empty) and the number of routes required to service all the stops. The mathematical models developed were programmed in FORTRAN IV for use on a

CDC 6400 computer and were applied to four schools. The authors report that in sixty-one seconds the computer developed an efficient routing system for one school with six possible bus route origins and ninety-six stops.

Describing a manual to be used by transportation officers for computing school bus routes, Boyer (1964) reviews mathematical techniques and reports on a comprehensive study made of criteria elicited from literature and interviews. Questionnaires were mailed to school authorities ranking the various factors involved and a computer program was then developed for optimum routing services. Some general conclusions are: (1) the greater the population density, the more efficient the program utilization; (2) shorter routes can be designed; and (3) because of varying conditions, no time estimates are given. Boyer reported that changes were in progress on the symbolic programming system (SPS) for further extension of efficient service.

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